OBSERVATIONS ON WOUNDFIN SPAWNING AND GROWTH IN AN OUTDOOR EXPERIMENTAL STREAM

Paul Greger[1] and James E. Deacon[1]

Abstract.— The response of woundfin to different substrates and current speeds was investigated in an outdoor experimental stream. Fish spawned in groups of 15–20 over 5–10 cm rock substrate in a .06 to .09 m/sec current at a depth of 10 cm. Eggs were adhesive on the undersides of the rocks. Fish spawned under these conditions grew to approximately 55–60 mm TL in 5 months.

The woundfin minnow, *Plagopterus argentissimus* Cope, is an endangered cyprinid presently occurring only in the Virgin River system of Nevada, Arizona, and Utah. Recent attempts at reestablishing this species in other areas of its original range in the Gila River Basin of Arizona have been unsuccessful. Almost 70 percent of the original woundfin habitat in the Virgin River has been rendered unreliable during part of the year by irrigation diversions (Deacon 1979). A variety of development projects involving modification of present river flows pose additional threats to the continued survival of the woundfin.

This study was undertaken to help identify habitat requirements for successful spawning. Such information is essential to an analysis of probable environmental impacts of various proposed development projects on the Virgin River as well as to the selection of areas within the former range of the species that might be suitable for reintroduction. Data on growth rates was taken to aid in an interpretation of a large data base on length-frequency of woundfin in the Virgin River.

Methods and Materials

Approximately 50 adult woundfin were collected from the Virgin River near the inflow of Beaver Dam Wash at Littlefield, Arizona, on 26 April 1980 and transported to the experimental stream facility on the University of Nevada campus in Las Vegas, Nevada. Many of the adults were robust, appearing in prime reproductive condition. Fish were immediately transferred to the stream facility upon arrival.

The stream (Fig. 1) consists of two raceway sections, a narrow upper section and a wider lower section, both constructed of concrete. Two pools, 2 × 2 m with a maximum depth of 1 m connect the raceways. The upper raceway is approximately 7 m in length and 45 cm in width, with a maximum depth of 15 cm. The lower raceway is 7 m in length and 90 cm in width, with a maximum depth of 45 cm. Current is generated by a 115 volt, 6.7 amp centrifugal pump that draws water out from the west pool through a circular rock filter. Water is pumped into the top end of the upper raceway, flows into the east pool, and then through the lower raceway into the west pool.

No filters were used to remove waste products but fresh well water was added daily to replace seepage and evaporation. This, in combination with low fish densities, seemed sufficient to prevent accumulation of ammonia or other harmful substances. The system design provides a choice of current speeds in the upper raceway as indicated for an average water level in Figure 1. Current speed in the lower raceway was too slow to measure with a Marsh McBirney hand-held, paramagnetic current meter.

We provided a choice of substrates by placing large rock (15–25 cm diameter), small rock (5–10 cm diameter), gravel, and sand in distinct segments in both raceways (Fig. 1). Daily observations of woundfin dis-

[1]Department of Biological Sciences, University of Nevada, Las Vegas, Nevada 89154.

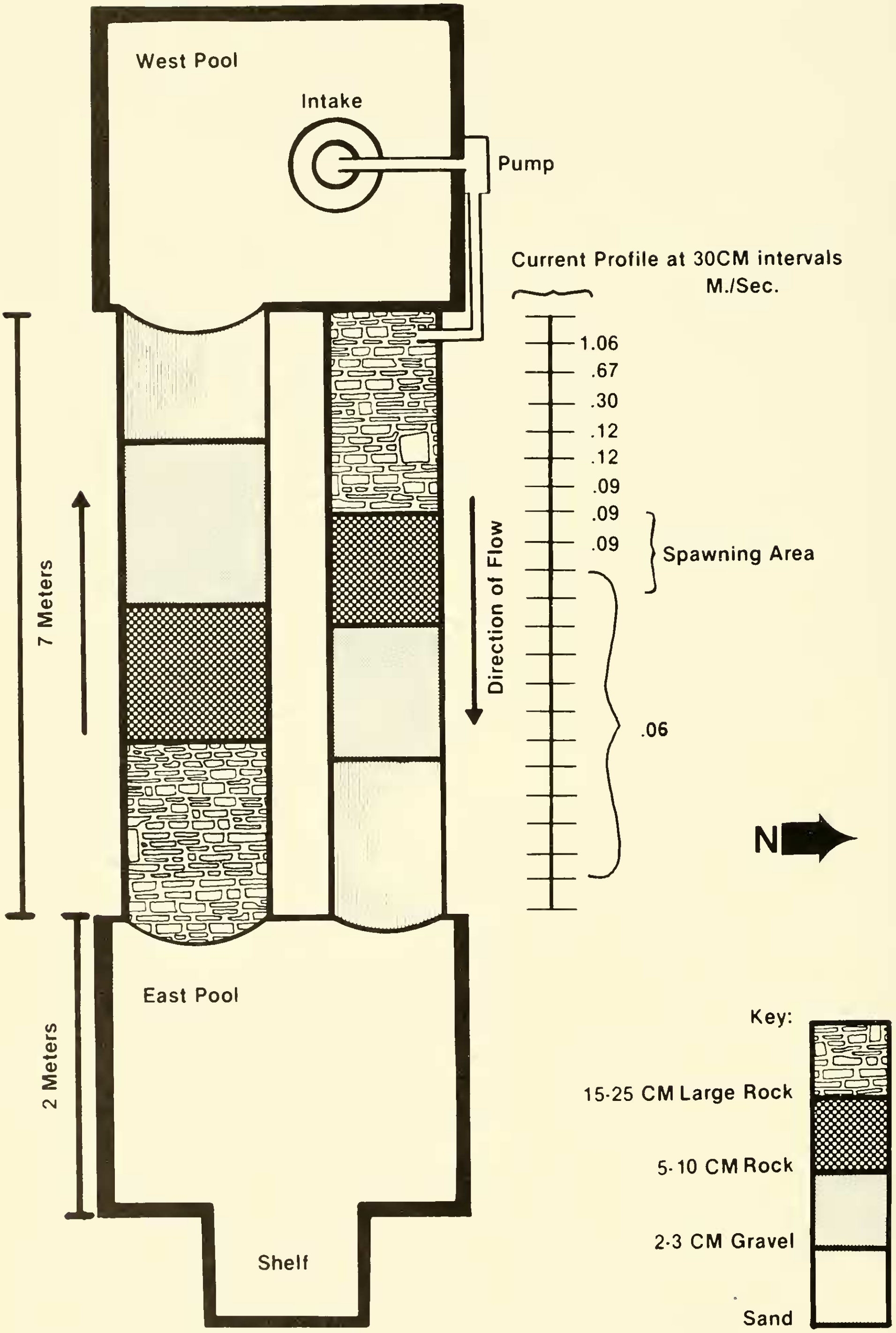

Fig. 1. Outdoor experimental stream at the University of Nevada, Las Vegas.

tribution and behavior in the stream system were made. Water temperature was measured with a mercury thermometer and a Ryan thermograph. Fish were collected, preserved, and measured at intervals to document growth rates of fry and fingerlings.

Collections are on deposit in the Museum of Natural History at UNLV.

Results and Discussion

Fish were placed in the experimental stream on 26 April 1980 and observed at irregular times each day. They usually occupied the deeper waters in the pools and swam in loosely organized schools. On 3 May a tightly packed wedge-shaped school of 15–20 adults was observed making many quick turns over the small rock (5–10 cm) substrate of the upper raceway where the current speed was .06–.09 m/sec and depth was 7–10 cm. The distinctive movements of this group were essentially confined to this 45 cm section and continued for about 40 minutes. Similar movements were noted on occasions over the next 9 days. These subsequent occasions involved 4–7 fish and lasted only 4–5 minutes. Water temperature was 25 C during each spawning event and fluctuated from 19 to 26 C during the period of spawning.

Spawning movements involved quick movements of the tightly packed school over the small rock substrate. Occasional flashing occurred, and at irregular intervals one or a few fish would leave the group and swim downstream to the pool below. Similarly at irregular intervals one or a few fish would swim upstream from the pool below to join the group. When fish entered the school, the group frequently would become more compact and appear to stop and vibrate as a group around the new arrival. This was assumed to be the spawning act. Immediately following it, the fish-to-fish distance would increase slightly, some individuals would pick at the substrate, and the main group would continue its tight circling movements over the small rock substrate. Although sex was not determined, we presumed that mature males dominated the school and that the fish entering and leaving were largely mature females.

Depth was uniform throughout the upper raceway. Current speeds of .06–.09 m/sec occurred over small rock, gravel, and sand substrates. Spawning activity was confined to the small rock substrate, where adhesive eggs were dropped between the interstices of the 5–10 cm rock.

Woundfin fry were first observed in the stream on 14 May. All fry were located in the lower section of the stream where currents were minimal (.01–.03 m/sec). Woundfin fry appeared to orient close to the edges of the raceway where current speed was slower or over a shallow shelf in one end of a pool. They did not occur over the deep water. The fry, when first observed on 14 May, were about 8–10 mm TL. Water temperature was about 20 C.

Close examination of the presumed spawning site on 15 and 17 May revealed adhesive eggs attached to the underside of the 5–10 cm rock in the upper raceway. This was further evidence that woundfin utilized the small rock substrate for spawning. Eggs were approximately 1.5 mm in diameter and had a brown center with a clear outer region. Some eggs were white and opaque. If a spawn did occur on 3 May 1980, the period of development is about 10–11 days. Data for other cyprinids is similar. For example, *Rhinchthys osculus* in the Chiricahua Mountains in Arizona required 6 days for hatching at 18 C plus 7–8 days to swim up from the interstices of the gravel (John 1963).

Fry of 9 mm total length were first observed to orient in current (.06 m/sec) over sand in the upper raceway on 15 May. These fry held position close to the bottom and edges of the raceway in slower currents. Fry also apparently selected areas of shade in the late afternoon. On 18 May woundfin fry appeared to be increasing their range of movements to include rock and sand substrates in the upper raceway. From 22 May to 12 June fry (10–13 mm) moved further upstream over gravel and rock substrates until by 24 June, 18.5 mm fish were observed moving over all substrates in the upper raceway. As woundfin increase in size, they develop an increasing ability to move into swifter waters. This suggests that in the environment woundfin of 18–20 mm total length are able to move away from areas with slow current into open water areas where current is moderate. Field observations are consistent with these data.

On 4 July the first schooling activity of fingerling was noted in the east pool. Some chasing behavior of fingerlings by adult woundfin was also observed. Finally, on 8 July, the stream was partially drained and about 100 woundfin fingerling were removed and transported to the National Endangered Species Hatchery at Dexter, New Mexico. Twenty-five woundfin were retained for further study of growth. Over the previous month, mortality related to an *Ichthyophthirius* infection had been substantial.

Information on growth of woundfin is given in Table 1. The first three weeks of the experimental period show little or no change in mean size. In fact, week 3 shows a slightly lower mean length than the previous week. This could have resulted from a second spawning or it could signal a difficult transition from yolk-dependent growth to food-dependent growth.

Weeks 4 and 5 show a growth increment of about 2 mm per week. Weeks 5, 6, and 7 show approximate growth increments of 4 and 5 mm per week. Thereafter, monthly measurements (July, August, and September) show growth changes of 12.4, 15.1, and 5.6 mm, respectively. Woundfin hatched in early May had reached a mean length of 35.7 mm by the end of July, 50.8 mm by the end of August, and 56.4 mm by 25 September. Observations were terminated on 25 September.

The stream was colonized by aquatic plants (*Chara* sp. and *Naja* sp.) and by a variety of macroinvertebrates (Ostracoda, Chydoridae, Chironomidae, Ephemeroptera, Anisoptera, and Coleoptera). Although a high protein commercial feed was supplied, it appeared that woundfin fry fed primarily on the natural foods present. These included Chironomid adults, pupae, and larvae and Chydorid crustaceans. Fry appeared to be in good condition.

TABLE 1. Weekly growth of woundfin fry and fingerling in an outdoor experimental stream. The mean length represents the average of all measurements made during the weekly period.

Week	Date	N	x̄ Length (mm)	Range (mm)
1	14–20 May	31	9.4	8.5–11.5
2	21–27 May	51	9.9	7.5–12.0
3	29 May–4 June	15	9.2	7.0–11.0
4	12 June	7	12.7	9.0–15.0
5	15–17 June	9	14.3	12.0–16.0
6	25 June	6	18.5	17.0–20.0
7	1 July	7	23.3	21.0–25.0
11	27 July	14	35.7	32.0–39.0
14	30 August	7	50.8	48 –55.0
17	25 September	8	56.4	49 –61.0

CONCLUSIONS

1. A small rock (5–10 cm diameter) substrate was specifically selected as the spawning substrate.
2. Spawning was accomplished when a gravid female joined a group of ripe males exhibiting spawning behavior over the proper substrate (depth was about 7–10 cm).
3. Woundfin eggs are adhesive and drop between the interstices of rocks, where they adhere to the underside.
4. Spawning of woundfin occurs primarily in the spring when water temperatures reach about 25–26 C during the diurnal temperature cycle.
5. Woundfin of 10–12 mm TL are restricted in their movements by current, but woundfin of 17.0–20 mm TL are able to move freely throughout the stream in a variety of current speeds.
6. Woundfin grow to about 50 mm in four months, a mean growth rate of about three mm/week. Growth may then slow, but an average size of 55–60 mm during the first growing season is not unlikely.

ACKNOWLEDGMENTS

Thom Hardy assisted in collection, transportation, and observation of woundfin. Tina Hardy assisted in maintenance of the stream and with observations of the fish. Their enthusiastic cooperation is much appreciated. This study was supported in part by Contract 14-16-0002-78-919 from the U.S. Fish and Wildlife Service. Permits were provided by the Arizona, Nevada, and Utah Fish and Game departments and by the U.S. Fish and Wildlife Service.

LITERATURE CITED

DEACON, J. E. 1979. Endangered and threatened fishes of the west. Great Basin Nat. Mem. No. 3:41–64.

JOHN, K. R. 1963. The effect of torrential rains on the reproductive cycle of *Rhinichthys osculus* in the Chiricahua Mountains, Arizona. Copeia 1963(2):286–291.